THE GREAT-VOLUME RAINSTORM AT ELBA, ALABAMA

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INTRODUCTION

The depth of rain which fell in the Elba, Ala., storm of March 14, 1929, is the greatest in the United States for most durations from 18 to 48 hours over large areas (from 10,000 to 100,000 square miles) [1]. At Elba alone a rainfall total of 21.4 inches was measured in a period of 32 hours ending at 1600 CST, March 14, 1929. Observers' notes and indirect evidence seem to indicate that almost all of this rain fell in the final 12 hours of the period. Figure 1 is the isohyetal map for the 24-hour period starting at 0300 CST, March 14. Figure 2 shows the depth-duration-area curves based on an earlier unpublished Hydrometeorological Section study of this storm. On the basis of the present study it is now considered likely that the 12-hour duration line in the smaller areas shows too little rain. The other lines are substantially correct.

The floods resulting from this rain were greater than any recorded before or since on rivers in southeastern Alabama [2, 3, 4]. (See [2] for photographs of Elba and Brewton, Ala., at height of flood.)

The storm's intensity over so large an area dictated its choice for study. Unfortunately, the Elba storm occurred before the present extensive network of upper-air stations, and so most of our knowledge must come from surface observations. There have been somewhat similar storms (synoptically) since the inauguration of widespread upper-air observations, but of lesser intensity (e. g., the storm centered in Louisiana on April 29, 1953).

A study of the surface maps for the storm period reveals a number of unusual features associated with the occurrence of the phenomenal rainfall. The primary purpose of this paper is to describe these unusual features. Some effort will also be made to offer tentative suggestions concerning the mechanisms involved.

[1] In cooperation with the Corps of Engineers, Department of the Army.

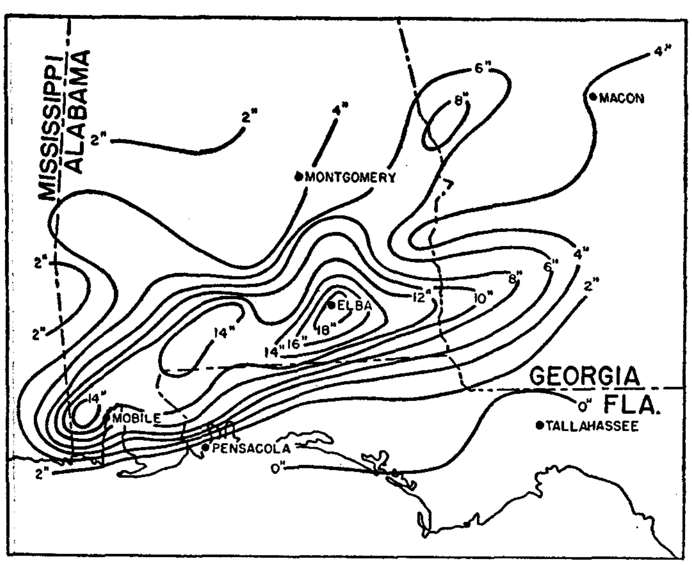

FIGURE 1.—Isohyetal map showin 24-hour rainfall for period starting 0300 CST, March 14, 1929.

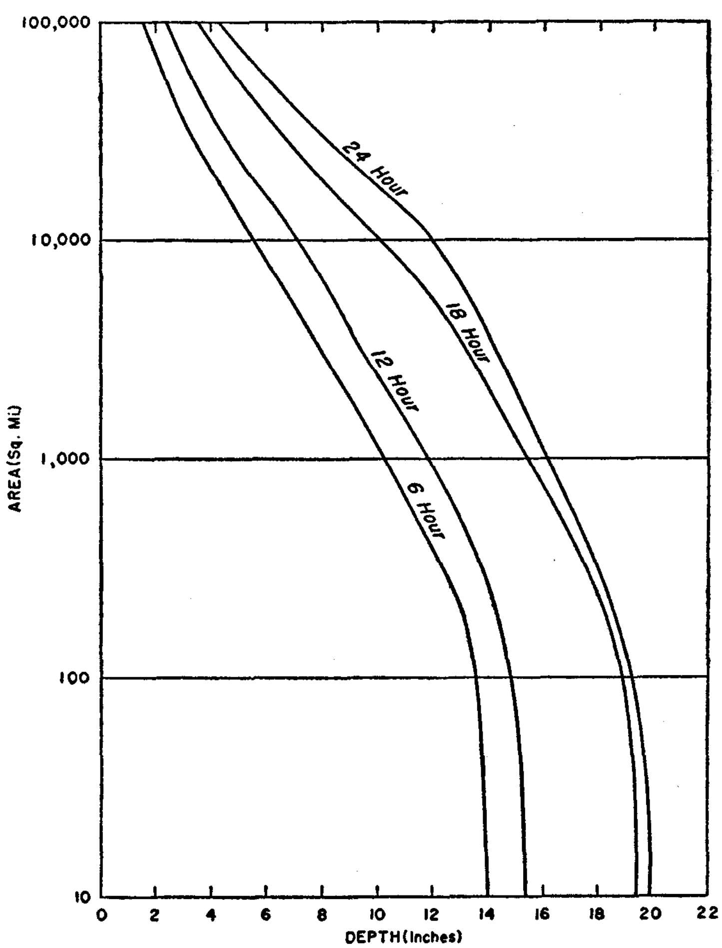

FIGURE 2.—Depth-duration-area curves for the Elba, Ala., rainstorm, March 14, 1929.

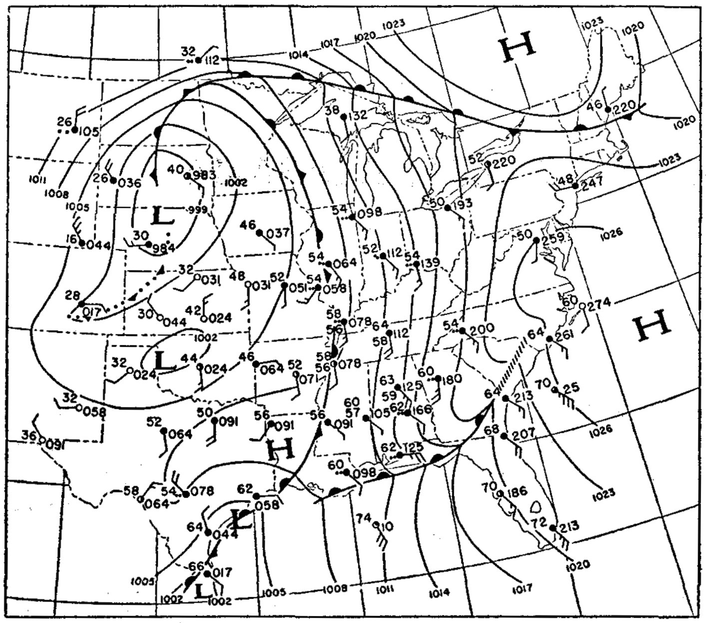

FIGURE 3.—Surface map for 0700 CST, March 13, 1929, about 24 hours prior to the storm at Elba.

GENERAL SYNOPTIC SITUATION

On March 11, 1929, a very deep trough including a cold front extended from about Bismarck, N. Dak., to Phoenix, Ariz., with mP air behind it. To the east, a large High of Arctic origin was centered near Cape Hatteras, directing a broad southerly current over the central part of the country. By March 12, a warm front had appeared in the Gulf of Mexico, with mT air to the south; rain was falling over a large area north of the front. Meanwhile, the deep mid-continent trough had moved slowly eastward with a well-organized surface Low near North Platte, Nebr., and the eastern High had moved slowly off the coast.

Figure 3, the surface weather map about 24 hours prior to the great storm, shows the warm front approaching Pensacola, Fla., from the Gulf. During the afternoon of the 13th the dewpoint at Pensacola rose from 61° to 66° F., while the surface wind shifted from east to south-

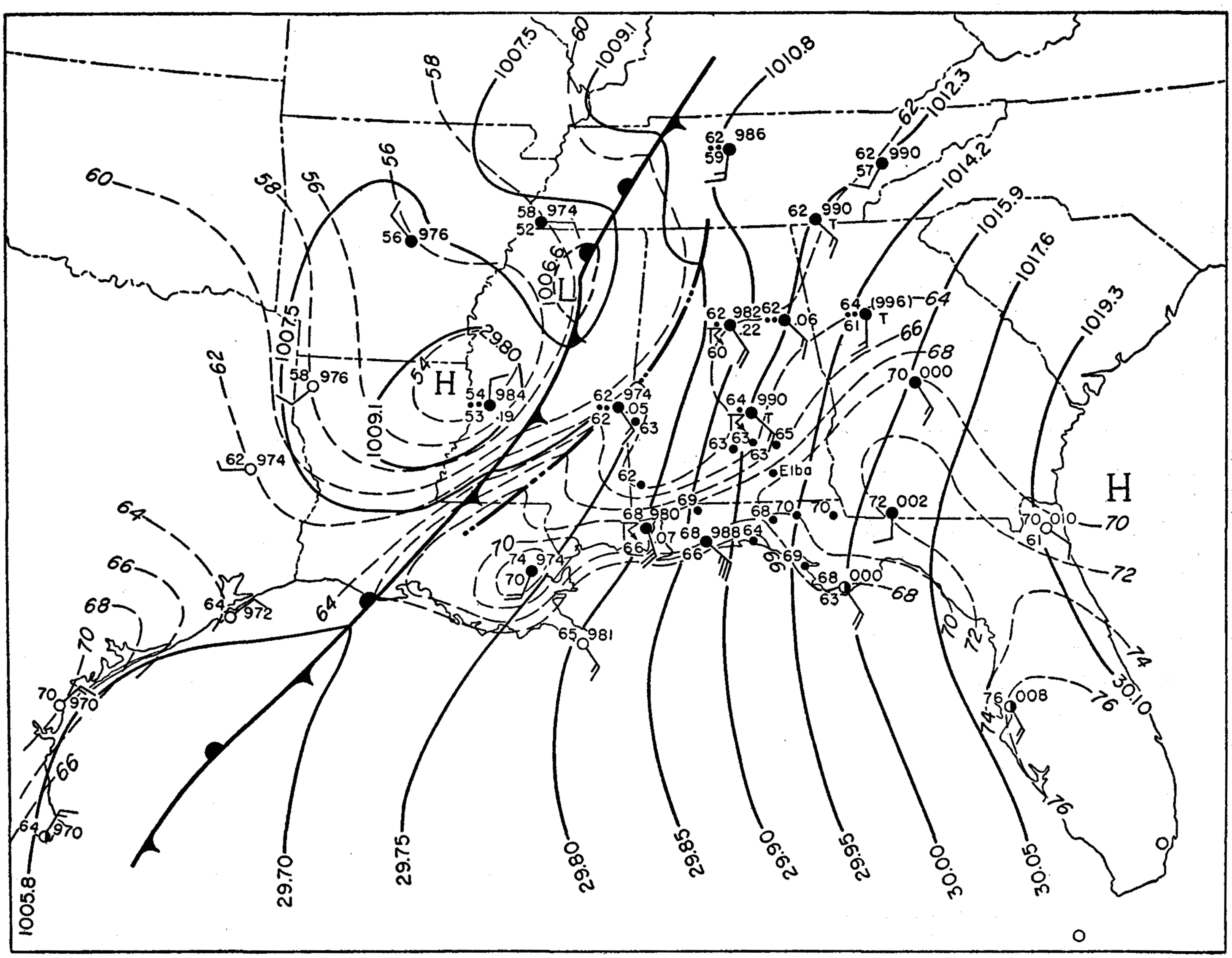

FIGURE 4.—Surface map for 1900 CST, March 13, 1929, about 8 hours prior to the Elba rainstorm.

east. After the frontal passage at Pensacola, no definite position for the warm front could be ascertained. The cold front, which had moved somewhat ahead of the surface mid-continent trough, was oriented north-south near the Mississippi River and extended into the extreme northwestern Gulf. North of Vicksburg, Miss., this front was moving slowly eastward, but in the Gulf of Mexico a very weak stable wave had formed about 50 miles east-northeast of Corpus Christi, Tex. The subsequent history of this stable wave was of great importance in the chain of events that led to the major rain-burst in the Elba storm.

DETAILS OF THE SITUATION

A series of hourly surface weather maps was analyzed for the 24-hour period starting at 1800 CST, March 13, 1929. The maps cover the States of Alabama, Mississippi, Georgia, and northern Florida in as great detail as possible. Figures 4 and 5 represent two maps from this series, those for 1900 CST, March 13 and 0700 CST, March 14. Cooperative observer synoptic weather data, including current temperature readings, for southern Alabama and northwestern Florida were also plotted on the charts. The rainfall amount, where plotted, is for the hour ending at the time of the map. Rainfall intensity is not differentiated by the weather symbol.

Figure 4, illustrating conditions about 8 hours before the deluge, shows a number of interesting features. The stable wave which had formed near Corpus Christi was centered in northern Mississippi, having averaged about 40 m. p. h. in its sprint from the Gulf. Four to five hours after the time of the map the wave passed Nashville, Tenn., causing a maximum wind of 26 m. p. h. from the southeast before the cold-front passage. A shower area, probably induced by the fast-moving wave, formed over Mississippi during late afternoon of the 13th. The line near Meridian, Miss., shows the approximate eastern boundary of this shower area (the instability line). At about 1930 CST this line passed Meridian, and in the next 14 hours passed, successively, Birmingham, Anniston, and Montgomery, Ala., and Atlanta and Macon, Ga. Every

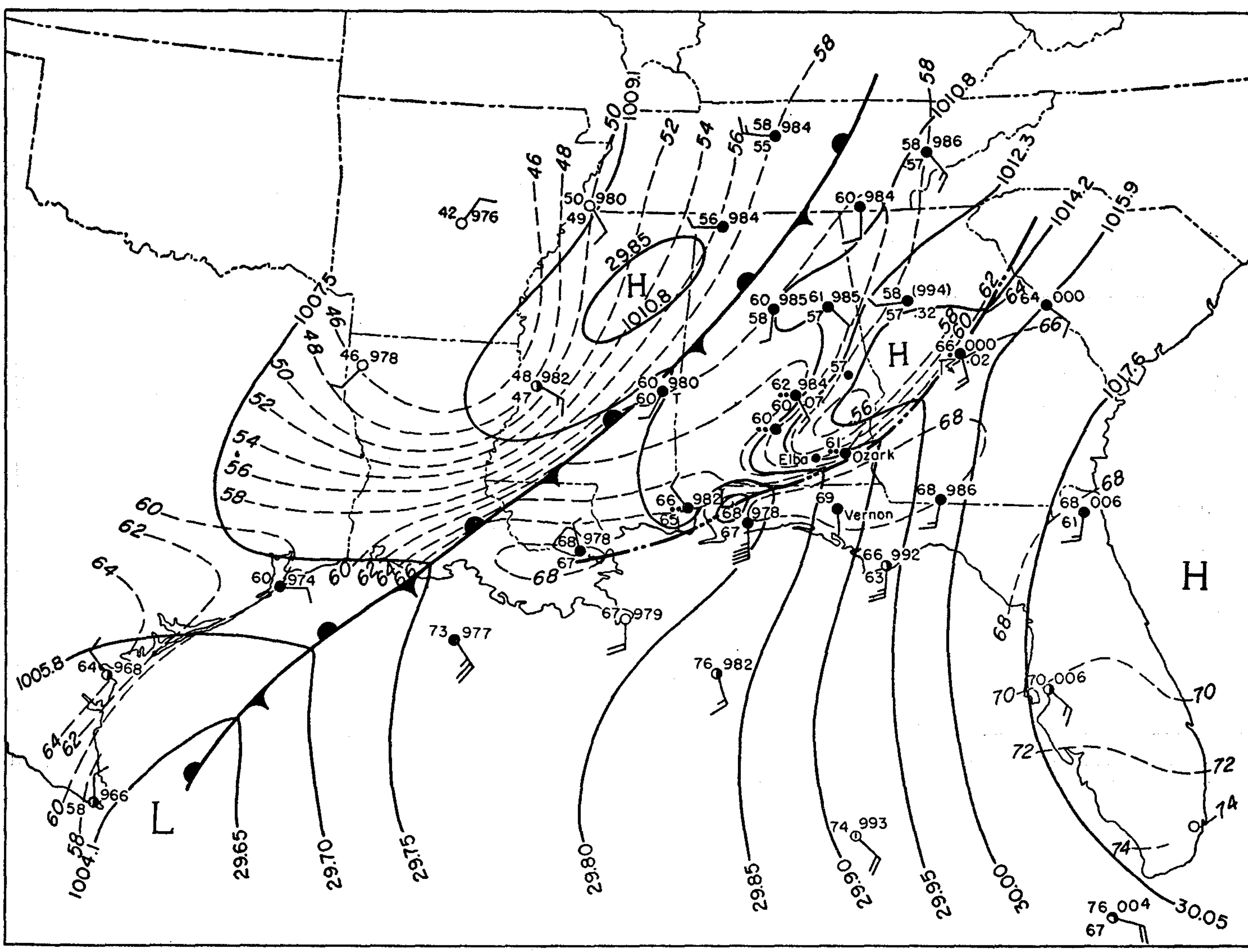

FIGURE 5.—Surface map for 0700 CST, March 14, 1929, the synoptic situation during the heavy rain.

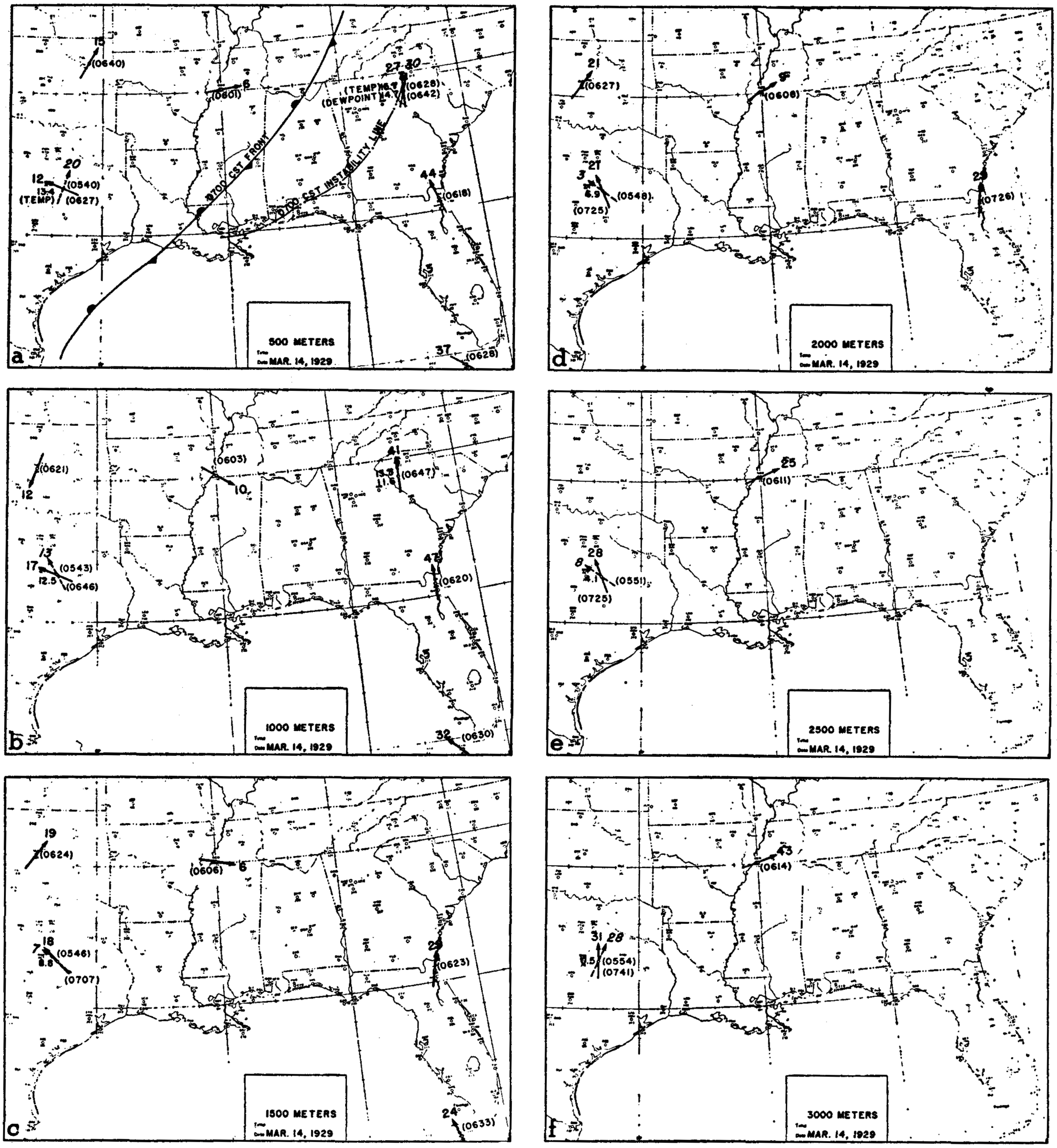

FIGURE 6.—Upper-level wind, temperature, and humidity data, morning, March 14, 1929. Time of observation (in CST) is given beside each wind arrow. Winds indicated by solid arrows were measured by kite soundings; dashed arrows indicate pibal measurements. Wind speed is shown in m. p. h. at end of arrow which flies with the wind.

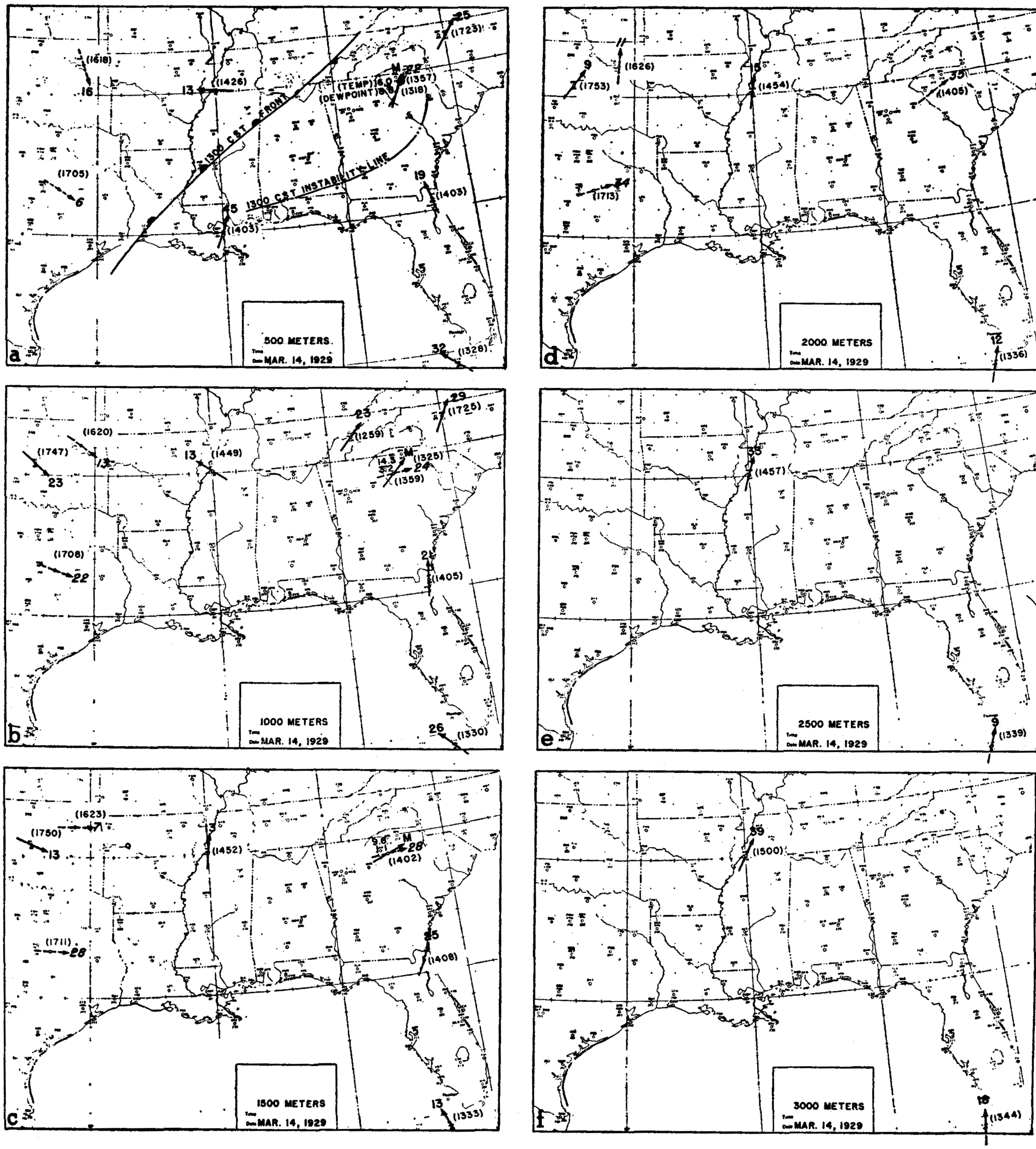

FIGURE 7.—Upper-level wind, temperature, and humidity data, afternoon, March 14, 1929.

weather station in the area, without exception, recorded this line passage. Weather changes at each of the stations included: (1) a sharp burst of rain, (2) a wind shift from southeast to northwest, (3) a rise in pressure, (4) a slight lowering of temperature and dewpoint, and (5) a return to a southeast wind, lower pressure, and a diminution of the rain. The temperature and dewpoint remained "permanently" depressed 2° to 6° F., however.

Cooling of an air mass in the lower levels by rain is generally attributed to a combination of factors including: (1) cooling due to the melting of sleet and snow at upper levels and the cold rain resulting therefrom at lower levels, (2) cooling of the earth's surface by the cooler rain and its partial vaporization, and (3) cooling by the moist adiabatic descent during the heavy rain [5]. A combination of these factors would be sufficient to lower the temperature by the observed amount (2° to 6° F.) without an air mass change at the surface.

Another significant feature pictured in figure 4 is the band of very strong winds between about 86° and 88° W. longitude in Florida and southern Alabama. Within this belt of high winds, moreover, the very strongest appeared to be south of latitude 31° N., probably because of the smaller frictional effect over the water. Although scattered showers and thunderstorms were observed in the high-wind area north of 31° N., rainfall amounts were generally light.

Figure 5 is a detailed view of the synoptic situation during the heavy rain. The strong-wind band had remained almost stationary during the 12-hour interval between 1900 CST, March 13 and 0700 CST, March 14, but had increased somewhat in intensity. The northern part of the instability line had reached Macon, Ga., while in the southernmost reaches it had become stationary between Mobile, Ala., and Pensacola, Fla. In this southern part the sequence of weather events at any given point was altered. Instead of the rain-burst lasting an hour or two, very heavy rain continued for many hours. For example, during the 7 hours that the line remained stationary between Mobile and Pensacola, Mobile recorded 6.24 inches of rain, while Pensacola recorded 0.08 inch. About noon (CST) the rain area retreated northward past Mobile. In extreme southeastern Alabama, in the Elba region for example, the rain area remained stationary an even longer time, about 12 hours. Late on the afternoon of the 14th the remnants of the rain area made a general retreat northward.

It will be noted that a warm front could be placed approximately from Mobile to Macon (in fig. 4) on the basis of a weak temperature gradient to the north of this line. This position coincides with the location of the instability line in figure 5, 12 hours later. The difficulties of placing a classical front in this position for 12 hours are that (1) the front would have had to remain stationary while a strong geostrophic component normal to the front in both warm and cold air was maintained, and (2) no observed data show a cyclonic wind shift. Under these conditions it would seem that ascribing the heavy rainfall to a warm front is to use a *deus ex machina*.

UPPER LEVELS

Data for 1929 are insufficient to draw upper-air charts for the southern United States. The available wind, temperature, and humidity observations aloft for March 14 are shown in figures 6 and 7.

The upper-wind observation nearest to the Elba center on the morning of March 14 was at Jacksonville, Fla. The southerly wind at that time was a maximum at the 1,000-meter level (fig. 6B). Low-level winds over northwestern Florida were probably much stronger than those over Jacksonville. It may be noted that a very strong southerly wind maximum at the 3,000- to 4,000-ft. level has been observed in several other great storms [6, 7]. This lower 3,000 to 4,000 feet is thought by the Hydrometeorological Section to be of great importance in the setup for very heavy rain. In the earlier storms, before the advent of the present dense network of upper-air stations, interaction of the wind and temperature fields aloft must be inferred. A fair approximation to the 3,500-ft. geostrophic wind can be obtained from the surface isobars. The cooling, observed at the earth's surface within the bounds of a rain area and due only to the effect of the rain itself, can be used to outline the area cooled through the lower 3,000 to 4,000 feet of the atmosphere. A sensitive measure of the change in wind speed, and thus of the differential temperature advection, is the 12-hour pressure change.

A POSSIBLE MECHANISM

On figure 5, 0700 CST, March 14, the axis of the surface cool air associated with the line of showers can be identified by the trough in the isotherms extending from Atlanta, Ga., to near Mobile, Ala. The temperature at Ozark, Ala. (very close to the storm center at Elba) was observed to be 61° F., while at Vernon and Pensacola, Fla., south of the instability line, the temperature was 69° and 68° F., respectively. This temperature gradient was observed during the heavy rainfall of the storm itself, while a slighter temperature gradient had been observed across the instability line earlier, as mentioned above. But, as the line approached the coast, warmer air was encountered, and thus the temperature contrast across the line was increased.

Meanwhile, as the temperature contrast increased, a pressure fall area moved in from the west (not shown) and was centered along the Gulf Coast at the longitude of Elba at about 0700 CST, March 14. The effect of this pressure fall was to strengthen further the low-level southerly winds in this area. Pensacola reported an extreme wind of 60 m. p. h. from the south at about 0900 CST, March 14.

It can then be inferred that during the morning of March 14 a low-level area of unusually intense temperature advection was set up near the Florida-Alabama line as a result of a combination of these two factors.

During the afternoon of the 14th a northward drift of the band of temperature gradient took place, probably occasioned by a shift in upper winds to a more southerly direction. A partial confirmation of this is contained in the Memphis 3,000-meter wind-aloft record (compare figs. 6 and 7). The great rain-burst thus came to an end.

SUMMARY

It is suggested that an instability line, with its attendant low-level cold air mass, created a concentrated temperature gradient over southern Alabama early on the morning of the 14th. At the same time an increase in the southerly winds took place due to a timely katallobaric area. The result was a narrow band of strong warm-air advection. This, together with the probably unstable character of the warm air mass, was responsible for the long, heavy rain in southern Alabama, centered at Elba.

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